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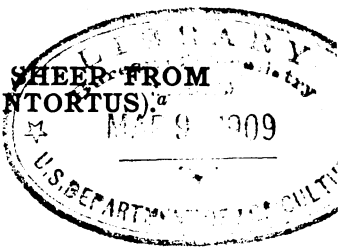

THE PREVENTION OF LOSSES AMONG SHEEP FROM STOMACH WORMS (HÆMONCHUS CONTORTUS).[a]

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INTRODUCTION.

The important problem of how to prevent losses among sheep from stomach worms is one for which, apparently, no solution that meets the wants of the practical sheep raiser has yet been discovered. After a preliminary investigation of the question it was hoped that such a solution might be reached, but in the light of further study of the life history of the stomach worm, combined with various experiments on sheep and lambs, the writer is less sanguine in regard to the matter.

Before proceeding to a consideration of measures which may be taken to avoid the injurious effects of stomach worms it may be well to discuss briefly some of the points relative to the behavior and life history of these parasites which have been brought out by investigation and experiment.

It is commonly noted that lambs are more severely affected by stomach worms than older sheep. The former become pale, thin, and weak, and finally die, or continue for a long time in poor condition and fail to grow as they should, while the adult sheep of the flock may remain in apparently good health. In such cases, however, it will be found if some of the older sheep are killed and examined that they as well as the lambs are more or less heavily infested with stomach worms. The reason, therefore, that the lambs are affected and the adult sheep are not, is because the latter possess a tolerance toward stomach worms not shared in an equal degree by the lambs.

The injurious action of stomach worms may be attributed to two things: First, the loss of blood abstracted by the parasites and the loss of nutritive materials which may be absorbed by the parasites from the alimentary fluids, and, second, the destruction of red corpuscles by a poisonous substance secreted by the parasites which is absorbed into the blood. Evidently the older, stronger, and larger sheep are better able than the lambs to withstand the losses of blood and nutritive materials and can better endure the loss due to the destruction of red corpuscles. Furthermore, there may be substances present in the blood of adult sheep tending to neutralize the poisonous matter produced by the parasites that are absent from the blood of the lambs,

[a] Reprinted from the Twenty-fifth Annual Report of the Bureau of Animal Industry (1908).

or that, if present, occur in smaller quantities. It is barely possible that some means of artificially producing in lambs an immunity against the evil effects of stomach worms may be devised, but at the present time this is only a matter for speculation and experimental research. Our present knowledge of the stomach worms leads us to direct our efforts toward bringing about freedom from infection, or, as the next best thing, reducing the amount of infection to a minimum and keeping it there.

LIFE HISTORY OF THE STOMACH WORM.

In the adult sexual stage stomach worms are able to live and carry out their reproductive functions only in the alimentary canal of sheep or other ruminants, occurring in the largest numbers in the fourth stomach. Each female produces thousands of eggs of microscopic size which do not develop into adult worms in the body of the host in which they are deposited, but, without hatching, pass out of the intestine in the feces. In a few hours, days, or weeks, according as the temperature is high or low, these eggs, if they are not killed by dryness or freezing—either of which is fatal to them—hatch out, and the tiny embryonic stomach worms then develop to what may be termed the final larval stage, or infectious stage. This later development likewise requires days or weeks, according to the temperature, and until the embryos have reached the infectious stage they appear to be fully as susceptible to freezing and drying as the eggs. Having reached the infectious stage, however, the worms are able to withstand long periods of dryness and severe cold, though some of them succumb comparatively early.

In the infectious stage the young worms are very active in the presence of moisture, and rapidly crawl up blades of grass and other objects whenever the relative humidity of the air is at a maximum, provided the temperature is above 40° F. or thereabout; below this temperature they are inactive. A decrease in the relative humidity, with the consequent evaporation of the moisture from the surface of grass blades and other objects, stops the migrations of the worms, and they become quiescent and remain in a condition of suspended animation wherever they happen to be at the time. During the next period of wet weather, dew, rain, or fog, they again become active and climb still higher on the grass. This crawling up grass blades is evidently most advantageous to the worm, as it thereby gets into a position from which it is much more likely to attain its final abode within the stomach of a sheep or cow than if it stayed down on the ground. When swallowed by a sheep or other ruminant, the embryonic stomach worm, if it has reached its final larval stage, whether active at the time or in a state of suspended animation, continues

its development and in the course of two or three weeks has reached maturity.

The length of life of individual worms in the stomach has not been determined. We have kept infested sheep in pens with board floors which were kept clean by sweeping and frequent scrubbing, feeding the sheep from raised racks and supplying water in a trough which was frequently cleaned, for varying periods up to a maximum of nineteen months, and found them still infested. As the possibility of reinfection by larval worms developing from eggs passed in the feces of these sheep was not entirely removed, though greatly minimized, the results obtained do not necessarily indicate that the worms present at the end of the period of observation were all present when the experiment was begun. The experiment, however, while it proves nothing as to the length of life of the adult stomach worm, demonstrates the futility of attempting to rid sheep entirely of stomach worms by simply keeping them away from pasture.

TREATMENT OF PASTURES.

The maximum period during which the larval stomach worms are able to survive on pastures is not definitely known, but it has been found that pastures on which infested sheep had grazed were apparently still infectious after a lapse of nearly eight months, namely, from October 25, when the infected sheep were removed, to June 16, when the pastures were tested by placing in them some lambs which had been raised under special precautions to avoid previous infection. In cultures made September 14, 1906, from the feces of an infested sheep and kept thereafter in the laboratory, most of the larvæ were dead but some were still alive, though very sluggish, on June 5, 1907, nearly nine months later. Cultures in which the embryos were allowed to develop to the final larval stage, after which they were kept in cold storage at temperatures below freezing—in some cases as low as 12° F.—still contained some living embryos after two or three months, while in other cultures eggs and embryos not yet developed to the final larval stage were killed within a few hours when exposed to temperatures below freezing. These experiments show that pastures may remain infected for several months after sheep are removed from them, and that the infection is not destroyed by cold weather. They also show that during a winter with more or less freezing weather there will be little or no increase in the amount of infection in pastures occupied by infested sheep. The eggs passed in the feces of the sheep will either be killed at once by freezing, or, on account of low temperatures above freezing, will remain dormant or develop so slowly that they are killed later by frost before they have reached the final

larval stage, which is resistant to cold. At the same time, while the infection of pastures may not be increased during the winter, the infestation of the sheep may be added to by their picking up from time to time larval worms which, prior to the beginning of cold weather, had already developed to the stage in which they are able to withstand freezing.

If sheep, goats, and cattle are kept out of a pasture for a year, it is fair to assume, upon the basis of our present knowledge, that all, or practically all, larval stomach worms will have died within this time. There is also little doubt that the period required for practically accomplishing disinfection of a pasture may be considerably shortened by plowing it up and placing it under cultivation. There are thus two ways by which a pasture may be disinfected, one by excluding sheep or other ruminants for at least a year, and the other by turning the pasture into a cultivated field. In view of the fact that any sheep which may be placed on disinfected fields or pastures will probably not be entirely free from infestation, it is not of much consequence whether every larval stomach worm in the pastures is dead or not. The approximation to this point which is attained by vacating pastures for a year or by plowing them up is sufficient for practical purposes.

METHODS OF PREVENTING THE DISEASE.

Taking up the question of preventing stomach-worm infection, it appears that at the present time the only method of handling lambs born of infested ewes that can be guaranteed to keep the lambs free from stomach worms is a method which is so impracticable that it is not likely to come into general use. As soon as born the lambs would have to be taken away from their mothers and raised by hand, never allowed to suckle, and be kept by themselves in places not previously occupied by sheep, cattle, or goats, all of which being subject to stomach worms are liable to leave infection wherever they happen to have been, which, it has been noted, may persist for many months. The possibility of the embryos of stomach worms reaching these places by drainage from infected areas, in hay cut from infected meadows, or in barnyard manure used for fertilizer, would also have to be excluded. Furthermore, the milk fed to these lambs, whether from sheep, goats, or cattle, would have to be pasteurized or sterilized in order to avoid the possibility of infection from this source, as some of the tiny embryos of stomach worms which might be present on the skin, wool, or hair of the animal from which the milk is drawn would be very likely to get into the milk during the process of milking and thus ultimately find their way into the stomachs of the lambs. Simple filtration of the milk would not insure the removal of the worms.

The experiment of filtering liquids containing embryonic stomach worms has been tried, using filter paper of the kind commonly used in laboratories for ordinary filtration, with the result that the worms readily passed through the filter.

THE BARE-LOT METHOD.

Methods of preventing stomach-worm infection less stringent than this have been tried with imperfect results. In the bare-lot method of raising lambs, devised by Dalrymple, the ewes and lambs are kept in an inclosure as free from vegetation as it can be kept, and are fed and watered from raised racks and troughs. Dalrymple found that when this method was used the lambs did not escape infection, and we have had similar experience.

PASTURE ROTATION.

In 1908 at the Experiment Station of the Bureau of Animal Industry near Washington, ten inclosures were constructed in a large field which had not been occupied by sheep or other ruminants for many years. Into inclosure No. 1 were placed a number of ewes and lambs which from the time the latter were born had been kept in separate pens except when turned together at intervals into another pen in order to enable the lambs to suckle, this pen being cleaned after each suckling period.

Prior experiments had indicated that the eggs and newly hatched embryos of the stomach worm would not develop to maturity if swallowed by sheep, and that the embryos must first develop to the final larval stage before they are able to complete their development when swallowed. In view of the fact that more or less time is required for the development from the egg stage which is found in the fresh feces of infested sheep to the final larval stage in which the young worms are ready to be swallowed, it was thought that the lambs might be kept for a time with the ewes in inclosure No. 1 without danger of infection, the danger point being reached when the sheep had been in this inclosure long enough for embryos to develop to the infectious stage from eggs in the feces of the infested ewes. In order to determine when the danger point would be approached cultures were made from the feces of an infested sheep two days before the ewes and lambs were placed in inclosure No. 1.

These cultures were kept outdoors near the inclosures and examined from day to day, other similar cultures being made at intervals of two to three days. As soon as it was found that the stomach-worm eggs present in any of the cultures had hatched and that the embryos had developed to the final larval stage, the lambs and ewes were moved to inclosure No. 2 in order to avoid infection with embryos in the in-

fectious stage, which the test cultures indicated would appear in this stage in inclosure No. 1 a couple of days later.

When the sheep and lambs were moved to inclosure No. 2, test cultures were again used as a guide to determine when the animals should be moved to inclosure No. 3, and so on throughout the entire series, the lambs alone finally being placed in inclosure No. 10. When the lambs were killed and examined after they had been in this inclosure about six months—namely, from July to December—some of them were found to be infested with stomach worms.

The infection of the lambs was evidently due to one or both of two things, namely, they became infected from larval stomach worms on the skin and wool of the ewes, whence the parasites were taken into the mouth by the lambs while suckling, or they became infected from worms which developed to the infectious stage in the various inclosures more rapidly than the test culture indicated. In either case it is clear that during the summer lambs can not be entirely protected from infection if kept with infested ewes, even though the flock be placed on fresh pasture at intervals much shorter than would be possible under practical conditions. In the experiment the sheep averaged less than nine days in each inclosure. Relatively few embryos in the test cultures had developed to the infectious stage when the sheep were changed from one inclosure to the next, the development of the majority proceeding much more slowly; but as it was desired in this experiment to keep on the safe side the sheep were moved as soon as the first appearance of embryos in the final larval stage was noted in the cultures. Even though the periods during which the sheep remained in the various inclosures had been lengthened to correspond to the periods required for larvæ in the infectious stage to become abundant in the cultures, the changes would still have been more frequent than would be practically possible, owing to the large number of clean pastures that would be required.

THE SUCKLING-PEN METHOD.

Dalrymple's plan of having a special suckling pen has also failed to prevent entirely stomach-worm infection in lambs from infested mothers. In the latest experiment with this method which has been carried out in this Bureau the ewes and lambs were placed in two small pastures which were free from infection at the beginning of the experiment, not having been occupied by sheep or other ruminants for a period of several years, the lambs occupying one pasture and the ewes the other. Until the lambs were weaned they were allowed with the ewes at frequent intervals for suckling in a small, bare pen from which all droppings were removed after each period of occupancy. After weaning, the lambs remained in the pasture which they had occupied before until some months later, when they

were killed and examined. Most of them were free from stomach worms, but in some the parasites were present in small numbers.

In earlier experiments the suckling-pen method gave more favorable results, and the writer was led to believe that it might be of some practical use. Since it can not be depended upon absolutely to prevent infection in lambs, as shown by the latest experiment, it is probably not of much practical value. It is not, however, a very troublesome method, as the ewes and lambs soon learn their way back to their proper pastures, and are easily separated after each suckling period. A noninfected pasture is required for the lambs, and since this pasture would become more or less infected as a result of the failure to prevent absolutely the infection of the lambs, it becomes necessary to employ a different pasture for the next crop of lambs, using the same pasture only in alternate years and excluding all ruminants from it in the interim in order to allow any infection which may be present to die out. However, fields adjacent to the ewe pasture might be utilized temporarily as pastures for the lambs and the necessity of maintaining two permanent lamb pastures thus avoided.

The failure of this method to prevent infection entirely is probably due to a circumstance already mentioned, namely, the more or less common occurrence of larval stomach worms upon the skin and wool of the ewes, whence they may sometimes be taken into the mouth of the lambs while suckling and be swallowed.

Inasmuch as there is no known method of handling lambs from infested mothers so as to avoid absolutely stomach-worm infection, with the exception of that in which the lambs are raised by hand, we must be content with reducing the amount of infection as much as possible and keeping the sheep and lambs in as good physical condition as practicable, so that they may be better able to tolerate the parasites from which they can not escape. In some cases it may be possible to employ the suckling-pen method to advantage in spite of its apparent impracticability. As to schemes for avoiding infection by the rotation of pastures, it is evident that a rotation plan, in which an attempt is made to keep pace with the development of the embryonic stomach worms by moving the sheep from one pasture to another before embryos hatching from eggs passed in the feces of infested members of the flock have developed to the infectious stage, is out of the question.

COMBINED PASTURE ROTATION AND MEDICINAL TREATMENT.

Recognizing the impracticability of moving sheep from one pasture to another frequently enough to avoid entirely the infection which develops in the pastures, we may next consider a plan for reducing infection by a combination of occasional rotation and

medicinal treatment. In following this plan some losses may occur during the first year or two unless noninfected pastures or fields are available to start with, but thereafter there should be no losses whatever.

This plan may be inaugurated at any time of the year. Supposing that it is to be begun just after lambing, say in March, it is advised that all of the sheep except the lambs be given a preliminary treatment with bluestone, coal-tar creosote, or gasoline, in accordance with the directions given in Circular 102 of the Bureau of Animal Industry. Any cattle or goats that may be on the farm must either be treated in the same manner as the sheep, being dosed for worms and moved from pasture to pasture in company with the sheep, or else be kept strictly apart from the latter in pastures of their own.

After the preliminary treatment, which will destroy a large proportion of the stomach worms that may be present, the sheep, lambs, and all other ruminants are removed to a pasture or field which may be termed pasture No. 1. Preferably this should be a pasture which is free from infection, but if such a pasture is not available, use an infected pasture, and some time in the summer, say the 1st of July, give the entire flock, lambs and all, another course of treatment and move them to a second pasture. The 1st of November another treatment for stomach worms is given, and the animals are moved to pasture No. 3, where they remain until the 1st of March. After this first year's treatment the medicine is given only in the fall, just before the sheep and cattle are moved to the pasture in which they spend the winter. On the 1st of March of the second year they are moved to pasture No. 4, then on the 1st of July to pasture No. 1, from which since July 1 of the preceding year all ruminants have been excluded, but which meanwhile may have been used if desired for live stock not subject to stomach worms, such as horses, mules, or hogs. November 1 the sheep and cattle, after being dosed for worms, are moved to pasture No. 2, from which, as in the case of pasture No. 1, all ruminants have been excluded since the corresponding date of the year before. Then in March pasture No. 3 is occupied again, and so on, from pasture to pasture in regular rotation.

By utilizing the pastures for other live stock during the periods that ruminants are excluded, the land included in the rotation scheme may be made use of more or less continuously. In lieu of some of the pastures, fields might be planted with suitable crops, and made to serve temporarily as pastures, and employed for other agricultural purposes, if desired, when not in use as pastures.

It is very probable, particularly in the case of badly infested flocks and farms, that the foregoing plan will at first fail to prevent entirely the loss of lambs from stomach worms. The flock should be watched closely, and if any of the lambs present symptoms of stomach

worms they should receive proper medicinal treatment. The pastures must not be heavily stocked, especially at first. The more numerous the sheep relative to the size of the pasture, the more heavily infested will the pasture become, and with close grazing the sheep are not only liable to pick up greater numbers of larval stomach worms, but also, unless auxiliary feeding is practiced, may not receive a sufficient quantity of food, and thus be less able to endure parasitic infection. As salt acts to a certain extent as a preventive against stomach worms, as well as being a necessary element in the diet of ruminants, it should be supplied to the sheep in liberal quantities. If possible the use of wet, low-lying pastures should be avoided, or this condition corrected by proper drainage.

The plan which has been outlined above may be variously modified. For example, in a climate with a cold winter season the same pasture could, if desired, be utilized every year as a winter pasture. The sheep would not be placed in this pasture until winter had set in, and would be removed again just before spring began. As already noted, any stomach-worm eggs passed in the feces of the sheep during the winter would either be killed immediately by exposure to freezing weather, or on account of the prevailing low temperature lie dormant or develop slowly with the practical certainty of being killed by freezing on some later occasion before they had reached the infectious stage. The order of rotation in this case would be as follows: Pasture No. 1 until July, pasture No. 2 until winter begins, then to pasture No. 3 (the winter pasture), then at the end of winter to pasture No. 4, then in July to pasture No. 1, then to the winter pasture (No. 3), then to pasture No. 2, etc.

FEEDING TOBACCO.

There has been considerable discussion recently in various live-stock and agricultural journals concerning the feeding of tobacco to sheep as a remedial measure against stomach worms. I will, therefore, in conclusion, briefly refer to some experimental work along this line conducted at the Experiment Station of this Bureau.

In June, 1908, a flock of sheep and lambs, in which stomach worms were known to be present, were separated into three lots with 5 lambs and 7 or 8 full-grown sheep in each, and placed in three similar small pastures. Lot 1 was fed leaf tobacco grown in Maryland, lot 2 tobacco cuttings obtained from a cigar factory, while lot 3 was fed no tobacco at all. Some difficulty was experienced in getting the sheep in lot 2 to eat the cuttings, and they finally had to be started on the leaf, afterwards changing to the cuttings, so that it was not until late in July that they really began to consume the cuttings. By the middle of August the sheep in each of lots 1 and 2 were consuming

10 ounces of tobacco every two days, an average per head of a little over two-thirds of an ounce every forty-eight hours. This represented the maximum which they would eat, and the feeding of this quantity every forty-eight hours was continued until early in December. There was no noticeable difference in the condition of the sheep in the three lots, which remained fairly good throughout the experiment. One lamb in the lot which was not fed tobacco died in July from unknown causes, no post-mortem examination being possible as the carcass was devoured by buzzards before the death of the animal was discovered. In the latter part of December and the early part of January the lambs and some of the ewes were killed and examined, with the result that stomach worms were found to be present in all three lots. In most cases there were only a few, but in one lamb several thousand stomach worms were found. Strangely enough this was a lamb from one of the lots which had been fed tobacco.

The conclusion reached in this experiment is that the feeding of tobacco had no noticeable effect either upon the stomach worms or upon the sheep. The results obtained can not be considered decisive, but they suggest the possibility that the favorable reports which have been made relative to tobacco as a remedy for stomach worms have been based on coincidences, the good results observed in such instances having been due to some other cause than the tobacco. In fact it has been noted that some sheep raisers who have tried tobacco have reported it a failure. At the present time, therefore, tobacco must be considered a remedy of doubtful efficiency so far as stomach worms are concerned.

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